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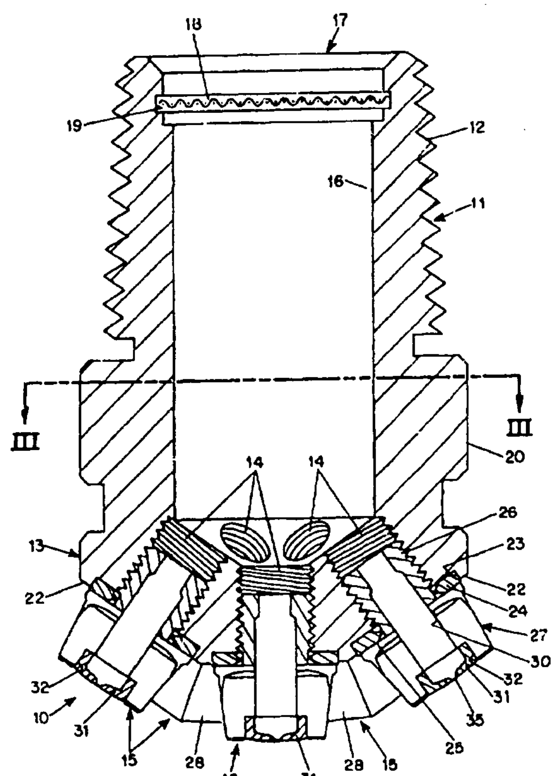
(54) Title: FIRE SUPPRESSION MIST NOZZLE ARRANGEMENT

(57) Abstract

In the particular embodiments described in the specification, a fire suppression mist nozzle arrangement consists of a cluster nozzle structure (10) including a nozzle head (11) having a continuous unobstructed passage (16) leading from an open end (17) to an end (13) containing seven, nine or thirteen nozzles (15) uniformly distributed about the axis of the structure (10) with one of the nozzles (15) being disposed on the axis and the others in one or more circular configurations about the axis. Each nozzle (15) has an unobstructed passage (30) communicating with the unobstructed passage (16) in the nozzle head (11) and terminates in an orifice member (31) having a large angle generally conical internal surface (33) leading to a smaller angle generally conical orifice passage (34) which leads to an orifice (35) having a diameter in the range from 0.007 inch to 0.4 inch (0.18 mm to 1 mm).



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Description

Fire Suppression Mist Nozzle Arrangement

Technical Field

This invention relates to fire suppression mist nozzle arrangements and, more particularly, to a new and improved, highly effective fire suppression mist nozzle arrangement.

In many instances, it is important to detect the presence or the threat of fire at a very early stage and suppress the fire promptly without flooding the threatened region with excessive quantities of water. In libraries, museums and computer facilities, for example, flooding by conventional water sprinkler systems often causes extensive damage in regions not directly threatened by a fire.

Background Art

Heretofore, it has been known that an active or incipient fire can be extinguished with a mist or fog of fine water droplets. These droplets are not only rapidly converted to steam so as to dilute the available oxygen supply and suffocate the fire, they are also effective to provide rapid cooling of the threatened region, reducing the possibility of combustion. Moreover, a mist of water also blocks transmission of radiant heat to prevent ignition of adjacent combustible materials.

Suppression or extinguishing of a fire with such fine mist also requires less water and therefore avoids or substantially reduces the damage which can result from excessive flooding of the threatened region with water, thereby preserving valuable property, such as books and papers, electrical and electronic equipment and the like from water damage. For this purpose it is desirable to generate a sufficient mist to blanket the area to be protected while at the same time applying water at a rate of no more than a few gallons (quadriliters) per minute for a period of no more than a few

minutes.

Conventional mist generating nozzles generally have a central passage leading to a small orifice and include a structure within the central passage containing a pin, plunger, vane, core or the like to control the rate and distribution of water and the size of water droplets supplied through the orifice. Such internal structures in the nozzle passage significantly reduce the velocity of the water emerging from the nozzle. Moreover, because of the small size of the mist droplets produced by such nozzles i.e. about 50 μm to 100 μm, they are strongly affected by air motion and have insufficient momentum to overcome air resistance. Consequently, such conventional mist generating arrangements are generally incapable of producing a mist which can be directed reliably and quickly from the location of the mist generator to a relatively remote location of an object to be protected, i.e., an object eight to twelve feet (three to four meters) or even farther from the mist generator. Instead, prior art mist generator arrangements have been designed to merely produce enough mist to fill the entire volume of the space to be protected. Because of the fine droplet size, however, the mist droplets tend to accumulate initially in the region of the mist generating nozzle. They also entrain air and hot gases which can adversely affect the distribution of the mist, requiring a substantial period of time for the mist to migrate to remote regions. Accordingly, such nozzles often protect only those objects within a range from about one to a few feet from the mist generator. Moreover, when the mist generator nozzle is located above a fire, the thermal updrafts created by the fire further impede motion of the mist toward the source of the fire.

The Sundholm Patent No. 5,433,383 discloses a fine mist suppression nozzle arrangement in which a spray head contains a central axial nozzle surrounded by four uniformly spaced nozzles with their spray axes disposed at an angle of 45° to the axis of the central nozzle. All of the nozzles are mounted in ducts leading to a common inlet duct in the spray head but the central nozzle is connected to the inlet duct

through a tube which is spring biased in the direction to close the ducts leading to the other nozzles whenever the water pressure falls below a selected value. In order to create a mist of small droplets with uniform distribution around the spray head containing the nozzles, each nozzle has a passage containing an internal whirler arrangement by which droplets having a size of about 60-80 microns are generated. The droplets are thus distributed about the nozzle to produce a fog pattern close to the nozzle which resembles a sponge with a relatively round head.

Another Sundholm Patent, No. 5,513,708, similarly discloses a spray head having a central nozzle and surrounding nozzles disposed at an angle thereto and includes a spindle in the duct leading to the nozzles to control the flow of water to them.

Similarly, the spray heads supplied commercially by Spraying Systems, Co. of Wheaton, Illinois, for industrial and agricultural applications bearing the trademark Fog Jet have a central nozzle and six surrounding nozzles disposed at an angle thereto and each of the nozzles has a central passage in which a core or vane structure is provided to control the size and distribution of water droplets in the spray. These mist generating arrangements are not only mechanically complex and expensive to manufacture but also tend to spread the generated water uniformly to produce a mist about the region of the nozzle rather than projecting mist toward a remote region to be protected.

Disclosure of Invention

Accordingly, it is an object of the present invention to provide a new and improved fire suppression mist nozzle arrangement which overcomes disadvantages of the prior art.

Another object of the invention is to provide a fire suppression mist nozzle arrangement which is effective to protect regions remote from the mist generator

without applying excessive volumes of water to those regions.

A further object of the invention is to provide a fire suppression mist generating nozzle arrangement having a simple and inexpensive structure with no moving parts.

These and other objects of the invention are attained by providing a nozzle head structure having an opening at one end and a substantially unobstructed internal passage leading to the opposite end and a plurality of nozzle-receiving openings formed in the opposite end which are substantially uniformly distributed about the axis of the nozzle head passage, each of the openings communicating with the nozzle head passage to receive water therefrom, and a nozzle disposed in each of the openings having an unobstructed internal passage leading from the nozzle head passage to an orifice.

Instead of using internal structures such as pins, plungers or whirlers in the nozzle passages and the nozzle head passage to control the generation and spray pattern of water droplets, the size and shape of the orifice and the passages leading to the orifice in each nozzle control the droplet size, droplet size distribution and pattern of water droplets. Moreover, these are controlled to produce a spray pattern from each nozzle which includes a substantially continuous central stream extending several feet (a few meters) from the nozzle to project the mist generated by the nozzle to remote regions to be protected.

The flow rate of water is controlled solely by the size and shape of the orifice and the pressure of the water supplied to the orifice and the small water droplets are produced by the shear forces resulting from the high velocity water stream passing through the relatively still air surrounding the water stream.

According to another aspect of the invention a nozzle for producing a fire suppression mist is provided in which the nozzle has an unobstructed internal passage leading to the nozzle orifice. By providing unobstructed axial passages in both the

nozzle head and the nozzles, a compact structure is produced which is inexpensive and simple to manufacture.

In a preferred embodiment the nozzle head has an internal passage with a substantially uniform diameter of about 0.4 inch to 1.0 inch (10 mm. to 25 mm.), preferably about 0.5 inch to 0.8 inch (13 mm. to 20 mm.) and each of the nozzle orifices has a diameter in the range from about 0.007 to about 0.04 inch (0.18 mm to 1 mm.), and desirably about 0.015 to about 0.025 inch (0.38 mm. to 0.64 mm.). Each nozzle orifice preferably has a length in the axial direction of the nozzle of about 0.001 inch to about 0.004 inch (0.025 mm. to 0.1 mm.), and desirably about 0.0015 inch to about 0.003 inch (0.04 mm. to 0.08 mm.), and the end of the passage within the nozzle adjacent to the orifice has a generally conical orifice passage leading to the orifice with a cone angle of about 80° to 130°, preferably about 100° to 120°, and with a base diameter of at least about 0.02 inch (0.5 mm.), preferably 0.025 to 0.05 inch (0.64 mm. to 1.27 mm). This orifice passage is surrounded by a generally conical surface having a cone angle greater than that of the orifice passage, such as about 130° to about 160°, preferably about 140° to about 150°, the diameter of the internal passage in the nozzle leading to the orifice being in the range from about 0.07 inch to about 0.2 inch (1.8 mm. to about 5.1 mm.) and preferably 0.08 inch to 0.1 inch (2.0 mm. to 2.5 mm.) and being unobstructed by any internal components.

With this nozzle and nozzle head arrangement, water applied to the nozzle head and to the nozzles mounted therein at a pressure of from about 500 psi to about 2000 psi (about 35 kg/cm. to about 140 kg/cm^2, and preferably about 1,000 psi (70 kg/cm.^{2}, is ejected from each nozzle in a substantially continuous central stream producing a pattern of small droplets. The droplets have a size of about 100-300 microns with the larger droplets being concentrated in the central stream and having a high momentum in the axial direction. Desirably, the continuous central stream extends from two or three to ten or twelve feet (one to four meters) from the nozzle

while being atomized and dispersed during its passage into small droplets to form a mist or fog. In this way, small droplets are continuously produced as the stream flows through the air and the droplets surrounding the stream are carried with the stream to a region relatively remote from the nozzle.

Moreover, the nozzle arrangement produce substantial turbulence in the mist pattern projected from the nozzles, causing the mist to migrate to and penetrate rapidly all parts of the volume in which the nozzle arrangement is mounted. Because of the turbulence of the mist pattern, the mist tends to be driven more readily into the source of a fire and into flames emanating from the source.

Preferably, one nozzle is mounted on the axis of the nozzle head and at least six nozzles are mounted in an adjacent generally conical head surface with their axes disposed at angles of about 35° to about 45° from the plane perpendicular to the nozzle head axis and distributed uniformly about the nozzle head axis. With this arrangement, a substantially uniform mist can be generated and projected quickly toward a region ten or twelve feet (three or four meters) or more from the location of the nozzle head so as to suppress incipient fires in that region and effectively protect objects in that region without requiring them to be flooded with water.

Brief Description of the Drawings

Further objects and advantages of the invention will be apparent from a reading of the following description in conjunction with the accompanying drawings, in which:

Fig. 1 is a longitudinal sectional view illustrating a representative embodiment of a mist nozzle arrangement in accordance with the invention;

Fig. 2 is an end view of the nozzle head used in the nozzle arrangement of Fig. 1;

Fig. 3 is a cross-sectional view of the nozzle head shown in Fig. 1 taken on

line III-III of Fig. 1 and looking in the direction of the arrows;

Fig. 4 is an enlarged fragmentary view illustrating the structure of the orifice region in the nozzles shown in Fig. 1;

Fig. 5 is a longitudinal sectional view illustrating a second embodiment of a nozzle arrangement in accordance with the invention;

Fig. 6 is an end view of the nozzle head used in this arrangement shown in Fig. 5;

Fig. 7 is longitudinal sectional view, taken along the line VII-VII of Fig. 8, showing a further representative embodiment of a nozzle arrangement in accordance with the invention; and

Fig. 8 is an end view of the nozzle head used in the arrangement shown in Fig. 7.

Best Mode for Carrying Out the Invention

In the typical embodiment of the invention illustrated in Figs. 1-4, the nozzle arrangement consists of a cluster nozzle structure 10 including a nozzle head 11 having a threaded shank portion 12 at one end to be received in a water supply line (not shown) and a closed opposite end 13 having a plurality of threaded openings 14 in which the plurality of nozzles 15 are threadedly mounted. An internal passage 16 of substantially uniform diameter leads from the open end 17 of the nozzle head to the threaded openings 14 which are substantially uniformly distributed about the area of the closed end 13. Preferably, a filter screen 18 is removably supported in a recess 19 at the open end 17 of the passage 16. Between the threaded shank portion 12 and the nozzle support end 13, the nozzle head 11 includes a region 20 with a hexagonal shaped periphery to facilitate mounting of the nozzle head in a water supply line.

In the embodiment shown in Figs. 1-3, the nozzle support structure at the closed end 13 of the head includes a generally conical end surface 22 having a cone angle of about 110°. It will be understood that the end surface 13 need not have a

geometrically precise conical shape but may have any shape generally approximating the shape of a cone. one of the threaded openings 14 in the nozzle support structure is disposed on the axis of the central passage 16 of the head and six other threaded openings 14 are uniformly spaced by angles of 60° around the head axis. Each of the six nozzles surrounding the central nozzle has its axis extending at an angle of about 55° with respect to the axis of the central nozzle. With this arrangement, each of the nozzles 15 is mounted in a recess 23 having a planar mounting surface at the outer end of each of the threaded openings 14 and the axis of each of the six nozzles surrounding the axial nozzle each extends at an angle of about 35° to the planar mounting surface of the central nozzle.

A metal sealing element such as a copper-brass washer 24 is interposed between the planar surface of each recess 23 and an engaging shoulder 25 at the end of the threaded portion 26 of the nozzle mounted in the recess. At its opposite end 27, each of the nozzles has an enlarged portion preferably formed with a hexagonal outer surface 28 to facilitate mounting of the nozzle in the nozzle-receiving openings 14 in the head.

In order to generate fine mist particles and at the same time produce a continuous central stream having sufficient momentum to carry the mist particles to a remote region, each nozzle has an unobstructed central internal passage 30 of substantially uniform size throughout its length leading to an orifice member 31 which is mounted in a corresponding opening 32 at the outer end of the nozzle 15. The orifice member 31 has an inner diameter which is substantially the same as that of the nozzle passage 30 and, as best seen in Fig. 4, the orifice member 31 terminates in a generally conical surface 33 having a cone angle of about 150° which in turn leads to a central generally conical orifice passage 34 having a cone angle of about 110°. As in the case of the end surface 13, the surface 33 and the passage 34 need not have a geometrically precise conical shape but may have any shape generally approximating

the shape of a cone.

At the end of the orifice passage 34, a central orifice 35 has a diameter in the range from about 0.007 inch to 0.04 inch (0.18 mm. to 1 mm.) preferably about 0.015 inch to about 0.031 inch (0.38 mm. to 0.79 mm.), and a length 36 from the end of the conical surface 34 to the outer surface 37 of the orifice member in a range from about 0.001 to about 0.004 inch (0.025 mm. to 0.1 mm.), preferably about 0.0015 inch to about 0.003 inch (0.04 mm. to 0.08 mm.), the diameter 38 of the base of the conical surface 34 where it intersects the conical surface 33 being at least about .02 inch (0.5 mm.) and preferably in the range from 0.025 inch to 0.05 inch (0.64 mm. to 1.27 mm.). In the embodiment illustrated in Fig. 1, having a total of seven nozzles 15, each nozzle passage 30 preferably has a diameter of about 0.1 inch (0.25 mm.) and the passage 16 in the nozzle head 11 preferably has a diameter of about 0.5 inch (12.7 mm.) and each nozzle orifice 35 preferably has a diameter of about 0.007 to 0.04 inch (0.18 mm. to 1 mm.) and desirably about 0.015 to 0.025 inch (0.04 mm. to 0.64 mm.).

With this orifice arrangement and nozzle head structure, water applied to the nozzle head at a pressure of approximately 500 to 2000 psi (35 to 140 kg/cm^2) and preferably about 1000 psi (70 kg/cm^2) will be ejected from each of the seven nozzles in a continuous central stream having substantial momentum which extends approximately 6 to 10 feet (2 to 3 meters) or more from the nozzle before breaking up. Each nozzle also produces a mist of fine droplets along its path which are carried to the remote region with the continuous central stream. Consequently, a region of, for example, 8 feet (2 meters) in diameter and located 8 to 12 feet (3 to 4 meters) from the nozzle arrangement may be rapidly blanketed with fine mist droplets in a density and distribution sufficient to extinguish an incipient fire rapidly without requiring the application of large quantities of water. The length of the continuous central stream and the width of the spray pattern vary with the size and length of the nozzle orifice and the shape of the passage lead to the nozzle orifice. By selecting appropriate

orifice sizes and orifice passage shapes the spacing and size of the region to which the mist is projected from each nozzle may be controlled.

In some cases it may be desirable to use a different orifice size in the axial nozzle than in the surrounding nozzles. For example, the best coverage for an eight foot (three meter) diameter region spaced eight feet (three meters) from a nozzle arrangement using a head with a 110° cone angle may be provided with an axial nozzle having a 0.015 inch (0.38 mm.) diameter orifice and surrounding nozzles having a 0.020 inch (0.5 mm.) diameter orifice.

Each nozzle having an orifice of 0.015 inch (0.38 mm.) diameter will project, for example, about one-quarter gallon (one liter) per minute when supplied with water at a pressure of about 1000 psi (70 kg/cm^2) . Consequently, with a nozzle head of the type shown in Figs. 1-4 containing seven nozzles, the remote region protected by the nozzle arrangement receives water at a rate of less than two gallons (eight liters) per minute. This is in contrast to conventional fire extinguishing sprinklers which are designed to apply water to a protected area at a rate of seven or more gallons (26 or more liters) per minute.

In order to activate the nozzle arrangement rapidly, water is preferably supplied to the nozzle head through a valve (not shown) which is activated in a conventional manner by a smoke detector, an ionization detector or other conventional device for rapidly detecting incipient fire conditions. With such early detection and prompt projection of a fire smothering mist toward a remote region to be protected, the nozzle arrangement of the invention is effective to extinguish incipient or active fires within time periods which may be as low as about one half minute to several minutes, while at the same time limiting the total quantity of water applied so as to reduce collateral water damage.

In the embodiment illustrated in Figs. 5 and 6, a nozzle head 40 has a structure similar to the nozzle head 12 of Figs. 1-3, terminating in a generally conical surface

41 having a cone angle of about 110°, but in this case the head contains an axial threaded opening 43 and eight threaded openings 44 uniformly distributed in a circle around the axial opening. Each of the threaded openings receives one of the same nozzles 15 described above with respect to the embodiment of Figs. 1-4 and the nozzles in the openings surrounding the central opening have axes disposed at an angle of about 35° with respect to the axis of the nozzle head. This embodiment can provide protection over a larger remote region, such as a region about ten feet in diameter spaced about ten to twelve feet (three to four meters) from the nozzle head and, in order to assure adequate blanketing of the periphery of that region with mist, it may be desirable to use nozzles in the openings 44 in the generally conical surface 41 having a larger orifice diameter than the orifice diameter of the nozzle disposed in the central opening 43. For example, the nozzle in the central opening may have an orifice diameter of 0.015 inch (0.38 mm.) and the nozzles in the openings surrounding the central opening may have orifice diameters of 0.025 inch (0.64 mm.).

In the further embodiment shown in Figs. 7 and 8, a nozzle head 50 terminates in a generally conical surface 51 having a cone angle of about 90°. This head has thirteen threaded nozzle openings, including a central nozzle opening 52, a first ring of six nozzle openings 53 surrounding the central opening, and a second ring of six nozzle openings 54 surrounding the first ring of openings 53 and a nozzle 15 mounted in each of the nozzle-receiving openings 53 and 54 having its axis extending at an angle of about 45° with respect to the nozzle head axis. It will be understood that the angular orientation of the nozzles in each ring surrounding the nozzle axis need not be the same. For example, the axes of the nozzles in the first ring may be oriented at about 35° or 40° to the axis of the nozzle head and the axes of the nozzles in the second ring may be oriented at a larger angle, such as 45° or 50° to the axis of the nozzle head. With this nozzle head arrangement, which produces a more uniform spray pattern than the other embodiments, protection may be provided for objects in

an even larger region remote from the nozzle head, for example, a region and twelve feet in diameter (four meters) twelve feet (four meters) or more from the nozzle head. In order to assure an adequate blanket of mist in the peripheral portions of the region, the nozzles mounted in the outer ring of openings may have a larger orifice diameter than the nozzles in the central opening 52 and the nozzles in the first ring of openings 53. With nozzle arrangements spaced even farther from the region to be protected, and using large nozzle orifices, even larger areas can be protected by a simple cluster nozzle arrangement.

In each of the above-identified embodiments, the length of the central axial passage in the nozzle head need be no more than about 1.2 inch (30 mm.) and the generally conical nozzle head end section 13 may have an axial length in the range from about .35 inch (9 mm.) to about .55 inch (14 mm.) depending on the cone angle of the generally conical end surface and the number of nozzle openings in that surface. Moreover, each nozzle has a total length, including the threaded end received in the threaded opening, of about 0.38 inch (9.6 mm.) and a length of about 0.2 inch (5 mm.) for the end projecting from the nozzle head end section 13. Thus, the overall length of the nozzle head with nozzles mounted therein is less than two inches and, with a threaded end portion of about 0.8 inches (20 mm.), the projecting part of the nozzle structure is only about 1.2 inches (30 mm.) in length and 1.5 inches (38 mm.) in diameter.

In accordance with the invention, therefore, a fire suppression mist nozzle arrangement is provided which has a simple and inexpensive structure with a compact configuration and no moving parts and which is capable of projecting a fire suppressing mist consisting of adequately sized water droplets to a relatively remote region to quench fires or incipient fires quickly and efficiently without excessive flooding.

Although the invention has been described herein with reference to specific

embodiments, many modifications and variations therein will readily occur to those skilled in the art. Accordingly, all such variations and modifications are included within the intended scope of the invention.

Claims

1. A fire suppression mist nozzle arrangement comprising a nozzle head having a substantially unobstructed axial passage extending inwardly from one end of the nozzle head and having a generally conical external surface at the opposite end of the nozzle head and a plurality of nozzle receiving openings therein, one of the nozzle-receiving openings being disposed on the axis of the nozzle head and the other nozzle-receiving openings being distributed substantially uniformly in one or more patterns surrounding the axis of the nozzle head, and a nozzle in each of the nozzle-receiving openings having a substantially unobstructed axial passage communicating at one end with the axial passage in the nozzle head and having at the other end an orifice with a diameter in the range from about 0.007 inch (0.18 mm.) to about 0.04 inch (1 mm.), the axis of each of the nozzles in the other nozzlereceiving openings being disposed at an angle in the range from about 30° to about 50° to the axis of the nozzle head.

2. A fire suppression mist nozzle arrangement according to Claim 1 wherein the axis of each of the nozzles in the other nozzle-receiving openings is disposed at an angle in the range from about 35° to about 45° to the axis of the nozzle head.

3. A fire suppression mist nozzle arrangement according to Claim 2 wherein the axis of each of the nozzles in the other nozzle-receiving openings is disposed at an angle of about 35° to the axis of the nozzle head.

4. A fire suppression mist nozzle arrangement according to Claim 2 wherein the axis of each of the nozzles in the other nozzle-receiving openings is disposed at an angle of about 45° to the axis of the nozzle head.

5. A fire suppression mist nozzle arrangement according to Claim 1 including from six to twelve nozzle-receiving openings distributed in one or more patterns surrounding the axis of the nozzle head.

6. A fire suppression mist nozzle arrangement according to claim 5 including six nozzle-receiving openings uniformly distributed in a circle around the axis of the nozzle head.

7. A fire suppression mist nozzle arrangement according to Claim 5 including eight nozzle-receiving openings uniformly distributed in a circle around the axis of the nozzle head.

8. A fire suppression mist nozzle arrangement according to Claim 5 including twelve nozzle-receiving openings uniformly distributed in two spaced circles around the axis of the nozzle head.

9. A fire suppression mist nozzle arrangement according to Claim 1 wherein the substantially unobstructed axial passage in the nozzle head has a diameter in the range from about 0.4 inch (10 mm.) to about 1.0 inch (25 mm.).

10. A fire suppression mist nozzle arrangement according to Claim 9 wherein the substantially unobstructed axial passage in the nozzle head has a diameter in the range from about 0.5 inch (12.7 mm. to about 0.8 inch (20 mm.).

11. A fire suppression mist nozzle arrangement according to Claim 1 wherein the substantially unobstructed axial passage in each nozzle terminates in a generally conical orifice passage leading to the orifice which has a cone angle in the

range from about 90° to 130°.

12. A fire suppression mist nozzle arrangement according to Claim 11 wherein the generally conical orifice passage leading to the orifice has a cone angle in the range from about 100° to about 120°.

13. A fire suppression mist nozzle arrangement according to Claim 11 wherein the generally conical orifice passage leading to the orifice has a base diameter of at least 0.02 inch (0.5 mm.).

14. A fire suppression mist nozzle arrangement according to Claim 13 wherein the generally conical orifice passage leading to the orifice has a base diameter in the range from of about 0.025 inch to 0.05 inch (0.64 mm. to 12.7 mm.).

15. A fire suppression mist nozzle arrangement according to Claim 11 wherein the substantially unobstructed axial passage in each nozzle has a generally conical internal surface with a cone angle in the range from about 130° to about 160° extending between the orifice passage and the side surface of the unobstructed axial passage.

16. A fire suppression mist nozzle arrangement according to Claim 1 wherein the substantially unobstructed axial passage in each nozzle has a diameter in the range from about 0.07 inch (1.8 mm.) to about 0.2 inch (5 mm.).

17. A fire suppression mist nozzle arrangement according to Claim 16 wherein the substantially unobstructed axial passage in each nozzle has a diameter in the range from about 0.08 inch (2 mm.) to about 0.1 inch (2.5 mm.).

18. A fire suppression mist nozzle arrangement according to Claim 1 wherein the orifice in each nozzle has a diameter in the range from about 0.01 inch (0.25 mm.) to about 0.03 inch (0.76 mm.).

19. A fire suppression mist nozzle arrangement according to Claim 18 wherein the orifice in each nozzle has a diameter in the range from about 0.015 inch (0.38 mm.) to about 0.025 inch (0.64 mm.).

20. A fire suppression mist nozzle arrangement according to Claim 18 wherein the orifice in the nozzle disposed on the axis of the nozzle head has a diameter which is different from the diameter of the orifice in at least one of the other nozzles.

21. A fire suppression mist nozzle arrangement according to Claim 1 wherein the orifice in each nozzle has a length in the range from about 0.001 inch to about 0.004 inch (0.025 mm. to 0.1 mm.).

22. A fire suppression mist nozzle arrangement according to Claim 20 wherein the orifice in each nozzle has a length in the range from about 0.0015 inch to about 0.003 inch (0.04 mm. to 0.08 mm.).

23. A nozzle for producing a fire suppression mist comprising a nozzle body having a substantially unobstructed internal passage which is open at one end and leads to a generally conical orifice passage at the opposite end which has a cone angle in the range from about 90° to about 130° and having an orifice at the outer end of the orifice passage with a diameter in the range from about 0.007 inch to about 0.04 inch (0.18 mm. to 1 mm.).

24. A nozzle for producing a fire suppression mist according to claim 23 including a generally conical internal surface at the inner end of the axial passage having a cone angle in the range from about 130° to about 160° extending between the orifice passage and the side surface of the substantially unobstructed axial passage.

25. A nozzle for producing a fire suppression mist according to claim 24 wherein the orifice passage has a cone angle in the range from about 100° to about 120°.

26. A nozzle for producing a fire suppression mist according to claim 23 wherein the orifice has a diameter in the range from about 0.015 inch to about 0.025 inch (about 0.4 mm. to about 0.64 mm.).

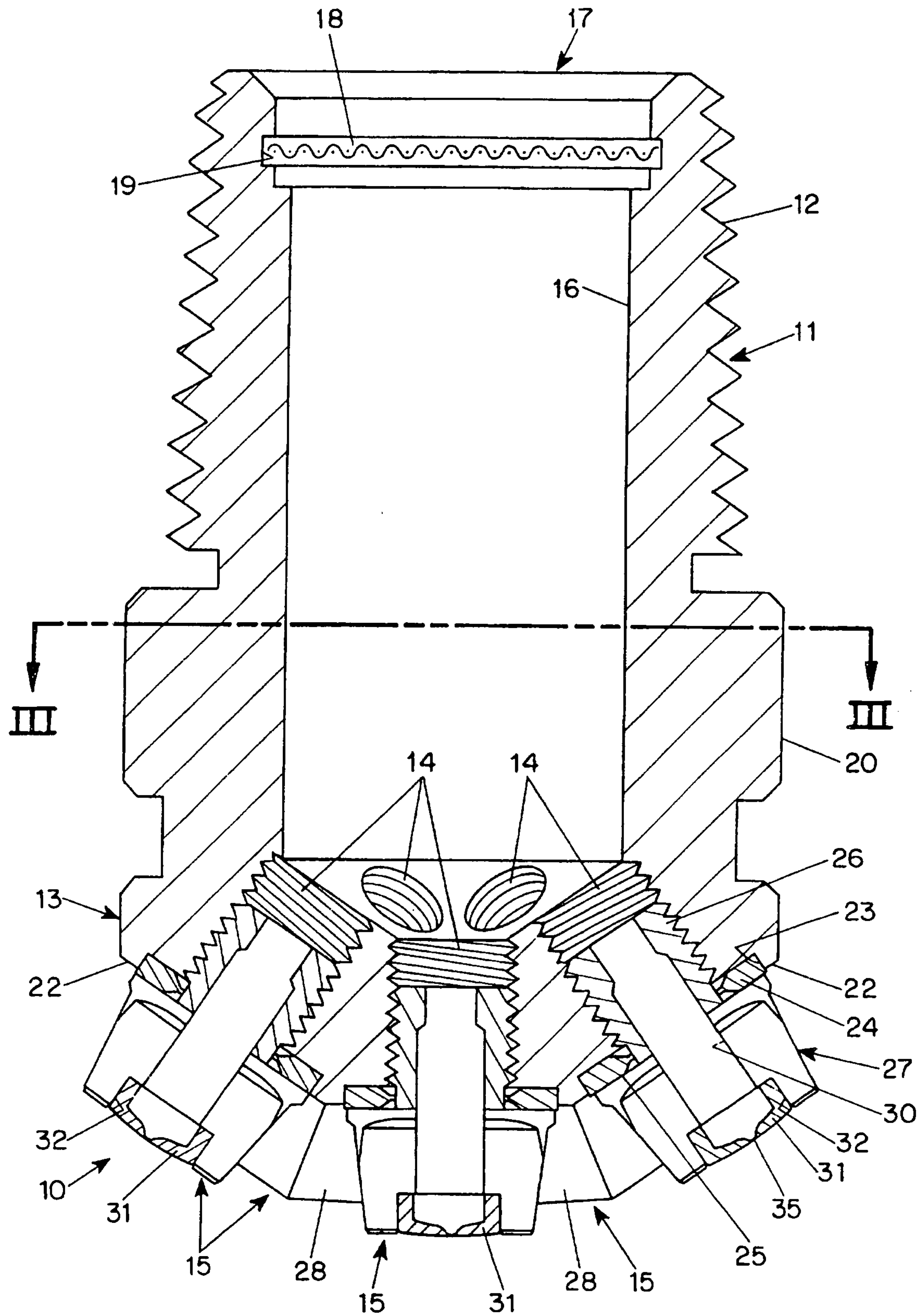
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FIG. 1

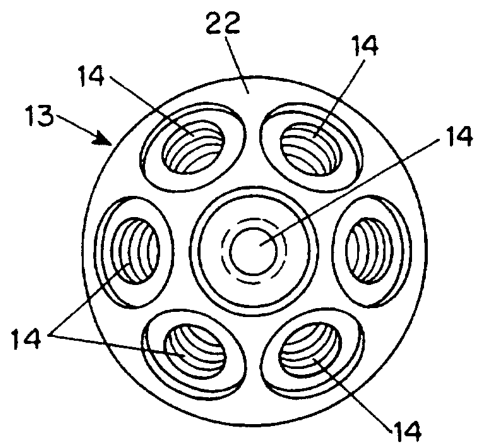

FIG. 2

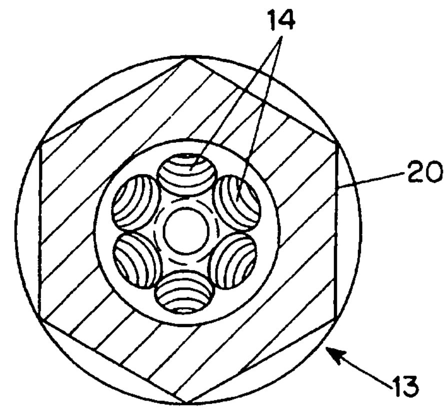

FIG. 3

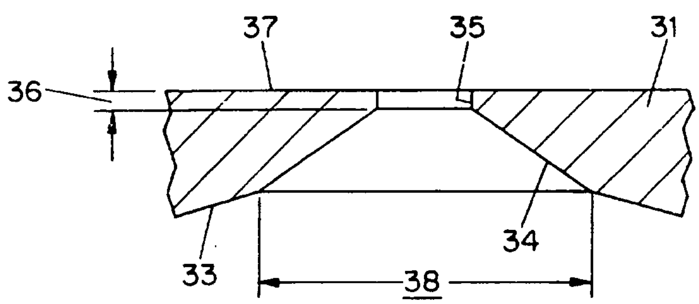

FIG. 4

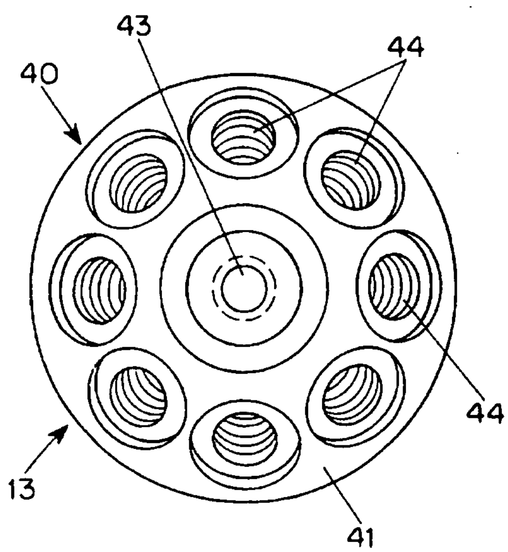

FIG. 6

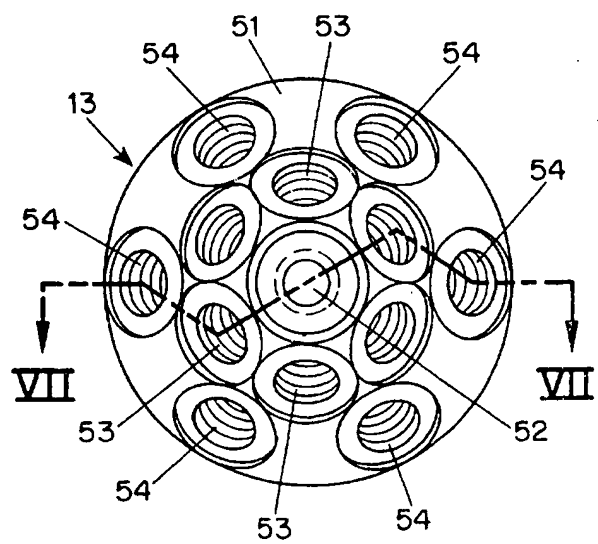

FIG. 8

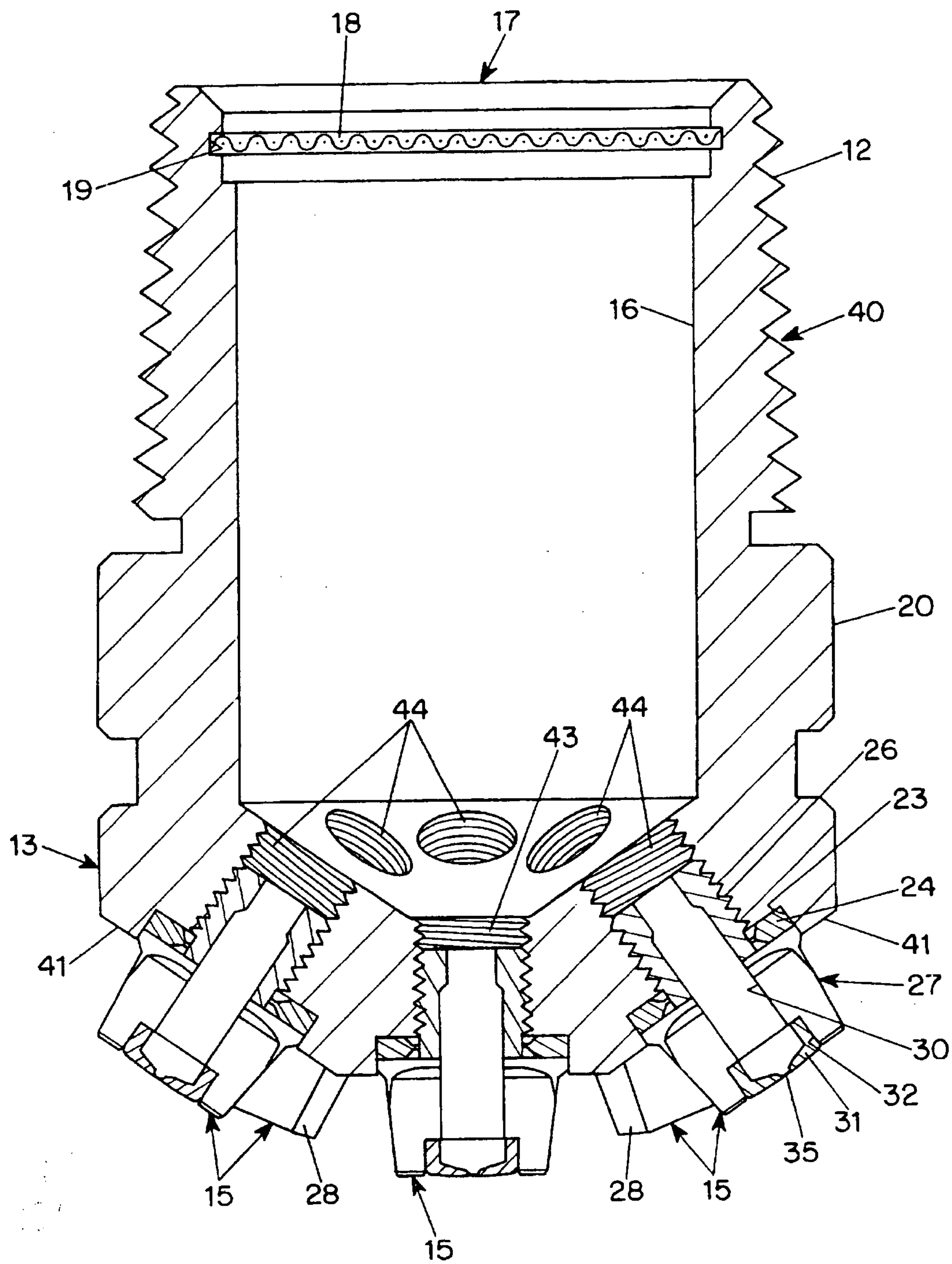
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FIG. 5

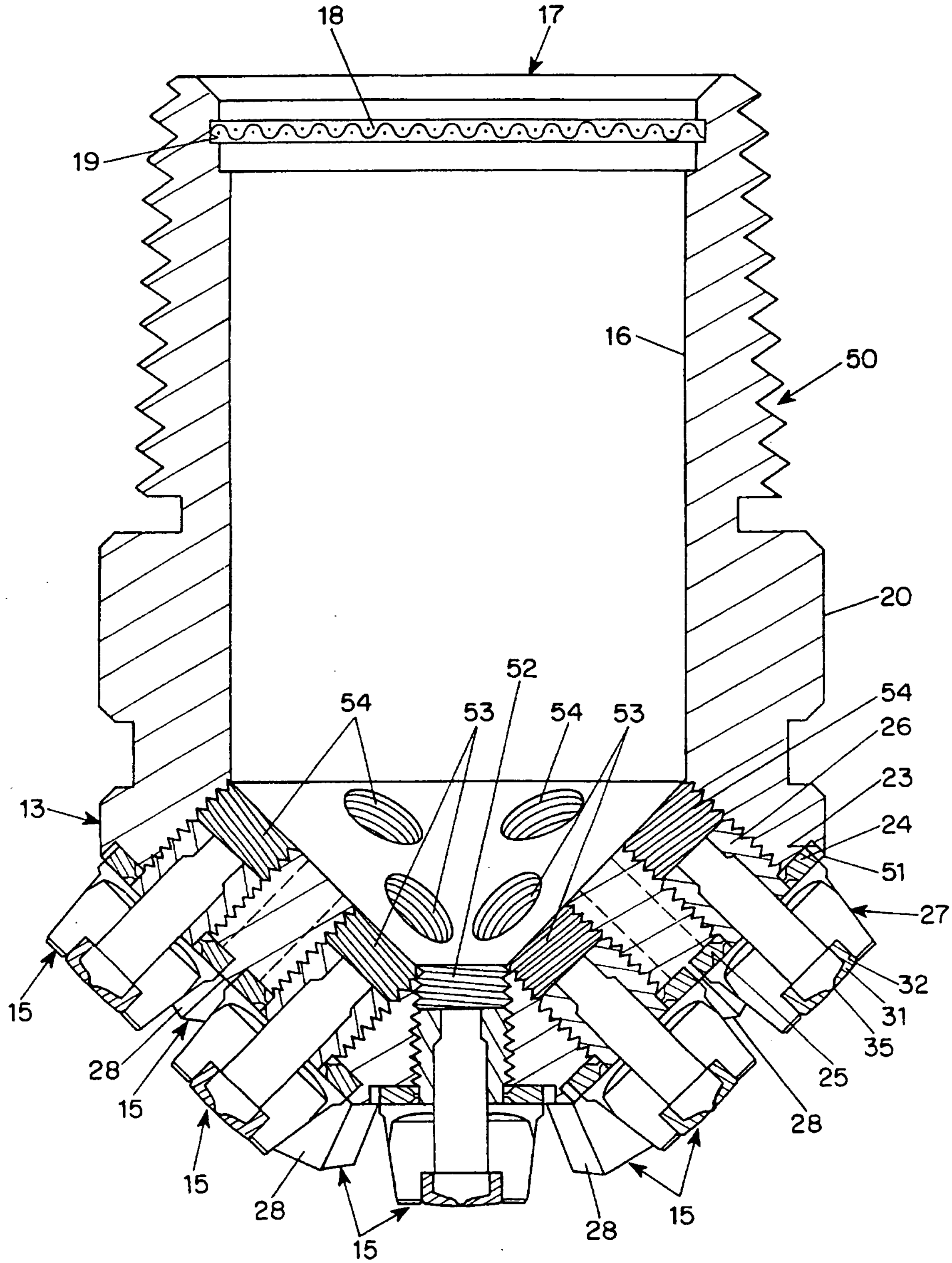
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FIG. 7

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US97/ 11974

A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) :A62C 2/08, 37/08; B05B 1/00, 1/14, 1/18
US CL :239/548, 550, 556, 558, 559, 560, 567, 591; 169/37
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 239/548, 550, 556, 558, 559, 560, 567, 591; 169/37

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	DE 388,141 A (LANNINGER) 10 January 1924 (10/01/24), Figures 1-3.	1-22
Y	US 2,726,897 A (DUPONT) 13 December 1955 (13/12/55), column 2 line 58 through column 5, line 41.	1-26
Y	US 5,154,356 A (SORENSON) 13 October 1992 (13/10/92), column 2, line 9 through column 7, line 60, figure 6.	1, 11-26
Y	US 5,433,383 A (SUNDHOLM) 18 July 1995 (18/07/95), column 2, line 4 through column 4, line 63, figures 1-3.	1-10
Y	DE 3,440,901 A (HERZOG et al) 11 July 1985 (11/07/85), abstract, figures 1 and 2.	1-10

[X] Further documents are listed in the continuation of Box C. [ ] See patent family annex.

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
12 SEPTEMBER 1997	06 OCT 1997
Name and mailing address of the ISA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231 Facsimile No. (703) 305-3230	Authorized officer STEVEN J. GANEY Telephone No. (703) 308-2585

Form PCT/ISA/210 (second sheet)(July 1992)*

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US97/ 11974

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5,501,282 A (SUNDHOLM) 26 March 1996 (26/03/96), column 1, line 46 through column 4, line 37, figures 3 and 4.	1-10
A	US 5,632,341 A (ALLEN) 27 May 1997 (27/05/97), column 4, line 8 through column 5, line 27, figures 1 and 2.	1-10
A	US 3,335,964 A (SINGLETON) 15 August 1967 (15/08/67), column 2, line 3 through column 3, line 22, figure 5.	11-26
A	CH 219,305 A (AKTIENGESELLSCHAFT) 16 May 1942 (16/05/42), figure 4.	11-26